The small fossils which I previously described and placed in the genus *Schutzia* are different from the present example, and their real claim to this genus may perhaps be open to question*.

Schutzia Bennieana comes so near the Permian species, that it is only after very careful consideration I have given it a specific designation †.

It gives me pleasure to name this plant after Mr. J. Bennie, to whom I owe so much for kind assistance in many points connected with my study of fossil botany.

Position and Locality.—In bituminous shale, water of Leith, opposite Kate's Mill, Midlothian; Calciferous Sandstone series. Collected by Mr. James Bennie.

IX.—*On the Fertilization of the* Florideæ. By Prof. F. Schmitz.

[Concluded from page 29.]

V.

The preceding description has by no means exhausted all the modifications presented by the process of fertilization and fructification in the Florideæ, as is shown by the fact that in almost every fresh genus that I investigated I detected new modifications of the previously observed processes. It is also sufficiently demonstrated by Bornet's statements with regard to *Spyridia*, *Callymenia*, *Crouania*, and other genera which I have hitherto been unable to examine. But the most important modifications of these processes have probably been shown in the foregoing in the described genera, which belong to the most different families of the Florideæ.

From this description it appears, however, that *throughout*, in the fertilization of the Florideæ a material connexion exists between the male cell, the spermatium, and the cell which is developed into the sporigenous tissue of the cystocarp (the "nucleus" of systematic botany). A fertilizing influence of

* Trans. Roy. Soc. Edinb. vol. xxx. p. 545, pl. xxxi. figs. 10, 11, 12.

† Schimper thinks the (?) *Trigonocarpus Rœssleri*, Gein. (Neues Jahrb. 1867, p. 288, pl. iii. fig. 4), is an analogous fruit, but specifically distinct (Traité d. Paléont. Végét. vol. ii. p. 358).

the union of spermatium and carpogonium upon a third, *distant* cell is never to be observed*.

The general result of the above description may, however, be briefly summarized as follows :—In all Florideæ a single male cell (*spermatium*) unites by open conjugation with the apex of the trichogyne of the female cell (the *carpogonium*); the cell-nucleus of the spermatium passes into the carpogonium and unites (apparently) with the cell-nucleus of the carpogonium. Then the ventral part of the carpogonium separates as a fertilized ovicell from the trichogyne. The fertilized ovicell, however, now becomes further developed in many different ways. It either grows directly into a bundle of branched ooblastema-threads, which finally produce the carpospores directly from their cells; or these threads enter into union with neighbouring cells of the sterile thallus-tissue for the obtentation of more abundant nourishment, and then produce the spores from their cells; or the individual cells of these threads enter into conjugation with cells of the thallus-tissue rich in contents, and afterwards produce pluricellular complexes of spores; or the cells of these ooblastema-threads evacuate the whole of their plasmatic contents, or a portion of

* As is well known the great accordance in the development of the fruit in Ascomycetes and Florideæ has already been repeatedly indicated in literature. This agreement appears particularly great since Stahl has succeeded in the Collemaceæ in tracing back the development of the apothecium to a "procarpium" of which the trichogyne is fertilized by spermatia. The preceding investigations on the fructification of the Florideæ have shown that a material connexion always exists between the two sexual cells, which concur in the act of fertilization, and the cell which in consequence thereof develops into the spore-fruit. The question now arises whether analogous conditions do not prevail also among the Collemaceæ and other similar Ascomycetes (and Ascidiomycetes?); whether in these also the fertilized "trichogynal cell" does not develop into an ooblastema-thread, and then one of the ooblastema-cells does not unite with one or more neighbouring auxiliary cells for the development of the tuft of filaments of the "ascogenous hypha." Various things seem to me to be in favour of this supposition, especially the great morphological agreement which exists in so many points between the Florideæ and Ascomycetes. But nothing certain for the decision of this question can be derived from the results of the extant investigations (of Stahl, Borzi, and Fisch), as these investigations started from quite different points of view, and therefore have not gone sufficiently in detail into the points which here essentially come under consideration. My own observations upon the development of the Collemaceæ have not as yet been sufficiently detailed and complete to render any decision of this question possible.

Further investigations will have to decide whether really (as it appears) perfectly analogous processes occur in the fructification of the Ascomycetes (and Ascidiomycetes?) and in that of the Florideæ, or whether in these groups of Thallophytes, notwithstanding external resemblance, essential differences prevail in the processes in detail.

them, under open conjugation, into analogous auxiliary cells, and these then produce pluricellular complexes of spores; or, finally, the fertilized ovicell itself empties the whole or a part of its contents, without any formation of branched ooblastema-threads, into the auxiliary cells immediately bordering it, and thereby causes these to produce pluricellular complexes of spores, or branched sporigenous filaments.

However, this last mode seems essentially to be confined to Florideæ with very dense and firmly closed cell-tissue (Gigartineæ, Rhodymenieæ, Spharococceæ, and Rhodomeleæ); but the development of widely spreading ooblastema-threads is chiefly proper to the Cryptonemieæ, Gelidieæ, and Squamarieæ, in which either the whole thallus, or the fructifying part of it, displays a gelatinous, soft or loose tissue. The fertilized ovicell becomes developed directly into simple bundles of sporigenous threads generally in such forms, the monœcious individuals of which develop numerous carpogonia and spermatia in close proximity, and make sure of the fertilization of numerous carpogonia by the quantity of these spermatia, so that it is not necessary, as in the preceding cases, in which the fertilizations of the carpogonia only take place singly, to use these up, and make them available in as many ways as possible.

In all these different cases, however, it comes finally to the formation of a sporigenous tissue-body of very variable size and form. This is sometimes seated upon the exterior of the thallus of the parent plant, or is enclosed, without any special envelope, in the tissue of the thallus; but generally this tissue-body forms a fruit-nucleus ("*nucleus*"), and is surrounded by a very variously formed envelope called the "pericarp" or "involucre." Both these forms are indicated in descriptive algology indifferently as "cystocarpia;" but such cystocarpia (as, indeed, appears from the foregoing description) are of very different origin in the different groups of the Florideæ, so that, for example, the cystocarpia of *Nemalion*, *Naccaria*, *Dudresnaya*, *Glœosiphonia*, *Chilocladia*, *Nitophyllum*, *Peyssonelia*, *Corallina*, and *Chondrus* are by no means equivalent in respect of their origin. Nevertheless the circumstance that in all these cases the sporigenous mass of tissue, whether naked or furnished with a wall, rises on the thallus of the parent plant as an independent fruit-body, sufficiently justifies the uniform designation of all these different forms of fruit.

If we compare the different process-details of the fructification with one another, it appears that, in the simplest cases, the ooblastema-cells directly and immediately produce the carpospores. In other cases these ooblastema-threads, for the purpose of readier and more abundant nourishment, first of all enter into union with the cells of the sterile thallus-tissue. In a later stage of fuller differentiation, special thallus-cells, the auxiliary cells, are already previously prepared for this purpose and abundantly furnished with contents; but the ooblastema-cells enter into a closer and closer union with them, which may advance to complete conjugation. Finally, the ooblastema-cell unites completely with the auxiliary cell to form a single cell, which now, for its part, takes on the function of the ooblastema-cell and carries it to completion; and at length there is no longer any development of pluricellular ooblastema-threads, but the ovicell itself (or a part of it) unites with the auxiliary cell. Thus, as the development of a simple process of nutrition, there results a process which, in its whole course, agrees perfectly with those processes which are designated as sexual processes of fecundation.

If in order to proceed quite securely we limit the discussion to the processes of fructification in *Glœosiphonia* which are comparatively easy to ascertain, the union of ooblastema-cell and auxiliary cell here shows all the characters of a sexual fertilization. The conjugation of the two cells and the transfer of the protoplasm of the ooblastema-cell take place in exactly the same way as in recognized processes of fecundation, for example in the fertilization of *Pythium* * and *Ancilistes* †; nay, it may even be ascertained that the cell-nucleus of the ooblastema-cell unites with the cell-nucleus of the auxiliary cell, as finally, after the evacuation of the ooblastema-cell into the auxiliary cell, only a single cell-nucleus is present. The consequence of this union of the two cells is, however, a new and very rapid growth of the auxiliary cell quite different from its previous growth, a growth which never occurs without a union of the auxiliary cell with the ooblastema-cell. Thus therefore *all* the conditions ‡ are fulfilled that can be required of a process which is to be regarded as a process of sexual fecundation; and certainly no one would

* De Bary, Beitr. zur Morphol. und Physiol. der Pilze. 4te Reihe.

† Pfitzer in Monatsb. Akad. Wiss. Berl. 1872, pp. 393, 394.

‡ If we leave out of consideration all inconceivable, mysterious, metaphysical qualities of sexuality only the following remain as common characters of all vegetable processes which have hitherto been by common consent recognized as sexual:—union of two (similar or differently developed) cells with fusion of the cell-nuclei, and a new and peculiar mode of growth of the conjugation-cell, which, without this conjugation, does *not* take place. In other respects the generally recognized processes of fecundation (to say nothing of the disputed ones) display the most multifarious differences.

hesitate to interpret this process in *Glœosiphonia* as a sexual act, if it were not that in the developmental cycle of this species there was already another process which must be regarded as a process of sexual fecundation. To assume a double act of fecundation in the developmental cycle of a single species is, however, in complete opposition to botanical conceptions,—that contradicts all tradition *.

But before the power of facts tradition must always give way. As a matter of fact the state of the case is that in *Glœosiphonia* the above-mentioned processes possess all the characters which have elsewhere been reckoned requisite for a sexual act. There is therefore nothing for it but either to embrace as a character in the definition of a sexual act, that it *can* occur only *a single time* in the developmental cycle of a species, and that of two processes, both of which possess the other requisite characters of an act of fecundation, only one is to pass as a sexual act; or to admit that in the developmental cycle of *Glœosiphonia* (and all analogous Florideæ) a sexual act is twice intercalated, a fecundation of the auxiliary cell following after the fecundation of the carpogonium†.

But if this amalgamation of ooblastema-cell and auxiliary cell must be recognized as a sexual act, there is thus thrown a very peculiar light upon sexuality in general. For here, among the Florideæ, the comparison of the different genera shows distinctly that the process which in *Glœosiphonia* displays all the characters of a sexual act, is to be referred, as it is distinctly observed in variously nearly allied Florideæ, to a simple act of nutrition, and has evidently originated from such a simple act of nutrition. In this way then sexual fecundation is tacked on to the simple vegetative nutrition of one cell

* Certainly Pringsheim (Jahrb. f. wiss. Bot. xi. pp. 18 *et seqq.*) has already distinguished, in the fecundation of the Thallophyta (and especially of the Florideæ), two distinct acts, which he indicates as "conjugation" and "connubium." But this distinction simply divides the individual sexual act into two steps, while in the present case we have actually to do with two separate sexual acts.

† At the same time it appears from the preceding description that the actual course of the second process of fecundation is somewhat different in different cases. In some instances (*Glœosiphonia*) this process takes on the form of a complete union of two cells; in other cases (Ceramieæ &c.) it would almost appear, as has already been pointed out, that in place of such an open conjugation the protoplasm (or the cell-nucleus) of one cell migrates through the separating membrane into the other cell. In this case the process of fecundation would display exactly the same differences which have been recently demonstrated by De Bary (Beitr. zur Morphol. und Physiol. der Pilze: 4te Reihe) in the fecundation of the Peronosporeæ (*Pythium, Phytophthora, Peronospora*).

by another *, and appears merely to be a peculiar further development of this process, which is so widely diffused in vegetable life, while otherwise sexual fecundation stands rather isolated among the processes of organic life.

But whether we regard this second act of conjugation in *Glœosiphonia* and other Florideæ as a sexual act or not, in any case this process has only been originated within the group itself †; in the simplest forms it is entirely wanting.

In these (*Nemalion* &c.) the course of development of the individual species proceeds as follows:—the vegetative plant proceeds from the germinating carpospore and develops sexual cells, after which the fecundated female cell grows upon the

* That by this I by no means wish to assert that the fertilization of a (female) cell by another (male) cell consists simply in the accession of fresh nutritive material (as indeed has been formerly asserted) needs no express declaration. In all cases the male cell, as also the female cell, is a formed *living* cell-body and not a "lump" of *lifeless* nutritive material.

† Just as this second sexual act has made its original appearance within the group Florideæ, so, evidently, may it also disappear again in the course of the development of this group, or instead of it the original first sexual act may be eliminated. In the first case the course of development of the species implicated will simply revert to the original form, and such forms might be hardly distinguishable from the primary simplest forms. On the other hand, if the first original sexual act disappears, the course of development of the species must thereby acquire a completely different aspect. For in this case the formation of spermatia must have entirely ceased; but, in exchange, either the individual spermatium mother-cells would develop directly into (simple or branched) male cell-filaments, which would fecundate the auxiliary cells, while the carpogonia entirely disappear, or no spermatium mother-cells at all would be formed, but instead of them the carpogonia would grow out directly into male cell-filaments (of course without preliminary development of a trichogyne). The final result, however, would be the same in both cases, namely the fertilization of auxiliary cells (produced sometimes from terminal cells, sometimes from joint-cells of the thallus-filaments) by the cells of shorter or longer, simple or branched cell-filaments.

This elimination of the first sexual act has, however, never been actually traced in the domain of the Florideæ so far as our present observations extend. It appears, however, to be realized among the Ascomycetes. Here, as already pointed out (p. 81, note), the Collemaceæ present such great analogies with the Florideæ that one may well assume that the formation of the fruit is in them brought about in the same manner as, for example, in the Cryptonemieæ. But in other Ascomycetes the above elimination of the first act of fertilization seems actually to have taken place in the course of development of the species, so that in these the second sexual act of the Florideæ has alone persisted as the sole sexual act; the mother-cell of the ascogenous hyphæ therefore represents a Floridean auxiliary cell (*Ascobolus* &c.). Nay (if, indeed, the extant descriptions really exhaust the actual processes), this second sexual act appears to have also frequently disappeared, so that the auxiliary cell, whether distinguished or not by its peculiar form from the other cells of the hypha, becomes developed apogamically into the spore-fruit.

parent plant itself into a spore-fruit, which, by the development of carpospores, brings back the whole developmental cycle again to the starting-point. This is exactly the same course that is displayed by the development of the Liverworts and Mosses,—the same sequence of alternating generations as in those cases. Thus it becomes easy in the course of development of these simplest Florideæ to recognize the alternation of generations of the Archegoniata, which, as is well known, we have accustomed ourselves to regard as the typical mode of vegetable development, so much so, indeed, that only the recognition of this alternation of generations in the individual case explains and renders intelligible the course of development in the group of plants in question *.

But these simplest Florideæ are approached most closely and distinctly, as has been shown above, by the other forms with more complicated fructification, and precisely by this distinct approximation enable us also to recognize clearly and distinctly in their development the above alternation of generations, although it has been here somewhat complicated by the intercalation of the second sexual act †.

But, independently of this complication, the above typical alternation of generations makes its appearance quite undisturbed and distinctly recognizable in the course of development of many Florideæ. In many other forms, however, still further complications of it occur, the vegetative generation dividing, as in the true mosses, into prothallium and leafy plant (*Batrachospermum* &c.). In numerous other forms, moreover, the tetraspores or bud-formations of various kinds are developed in the vegetative generation as accessory organs of increase, whether they are produced upon the sexual individuals themselves (*Cruoriopsis cruciata*, Duf., *Petrocelis Ruprechti*, Hauck, &c.) or confined to special neutral individuals (as in most Florideæ).

Lastly, in many Florideæ there seems to be associated with the above typical alternation of generations (corresponding to

* That in such an explanation of the course of development of a group of plants we have to do with a perfectly analogous process, as in the explanation of the more complicated forms of flowers of Phanerogamia, which are explained and made intelligible (see Schmitz, 'Die Familiendiagramme der Rhöadinen') by comparison with other previously known flowers, will not be hard to see upon consideration.

† In these forms of the Florideæ (*Glœosiphonia* &c.) we can if we like distinguish series of three generations, as here the female sexual cell of the simpler Florideæ (*Nemalion* &c.) is replaced by two cells, the carpogonium and the auxiliary cell, and between these a new third generation is intercalated.

the alternation of generations of the Archegoniata) * a still further complication, a regular alternation of sexual individuals and (single or numerous successive) tetraspore-individuals being developed. This at least seems to be indicated with great probability by the fact that, of many short-lived Florideæ, sexual plants are to be met with only at particular seasons, while neutral plants are to be found either throughout the year or, at any rate, for a considerable time. Certainly, however, no instance of such a regular alternation of neutral individuals and sexual individuals (which in itself might be regarded as a particular kind of alternation of generations) has hitherto been demonstrated with certainty by observation.

VI.

The whole process of development of the simplest Florideæ approximates them, as has repeatedly been pointed out in literature, very nearly to the Chlorophycean group of the Coleochæteæ.

In both groups of Algæ the entire body of the plant is composed of ramified cell-filaments with apical growth, and the joints of which are never transversely divided, and these are more or less closely pressed together laterally. In both groups of Algæ the sexual cells originate from terminal cells of these cell-filaments †. Small terminal cells develop from their entire protoplasm single naked male cells; individual larger terminal cells become inflated into female cells, and extend from their apex a longer or shorter thin trichogyne. But in the Coleochæteæ these trichogynes open at the joint; the protoplasm of the female cell, even before fecundation, cuts off an unserviceable portion as a directive body, and evacuates this through the open apex of the trichogyne; further, in the Coleochæteæ the naked male cells are spontaneously motile by means of two cilia; and, lastly, in the Coleochæteæ the fertilized ovicell first of all passes into a resting state, and only after this period of rest develops a cell-body, which leads to the formation of motile "carpospores."

All these last-mentioned points, to which may be added, as less important matters, the difference of the assimilation

* Pringsheim some time since (Jahrb. für wiss. Bot. Bd. xi. p. 6) expressed an essentially different view of the sexual alternation of generations of the Florideæ. But it would lead us too far to enter here in any detail into the differences of the two conceptions.

† In the position of the sexual cells, according to the extant statements (Pringsheim, in Jahrb. für wiss. Bot. Bd. ii.), some species certainly show a different character, inasmuch as they develop their sexual cells from joint cells of the thallus-filaments.

colouring-matters and of the solid assimilation-products, are of sufficient weight to make an *immediate* annexation of the Florideæ to the Coleochæteæ impossible; but, on the other hand, the agreement pointed out between the two forms is so great that, in the natural system of the Thallophyta, the simplest Florideæ may be arranged next to the Coleochæteæ, and consequently the whole of the Florideæ or Rhodophyceæ next to the Green Algæ or Chlorophyceæ *.

On the other hand, I can by no means regard another relationship of the Florideæ, so often dwelt upon of late, the relationship to the Bangiaceæ, as so close as is supposed. This group of Algæ which we have lately been accustomed simply to arrange among the Florideæ, on the ground of Berthold's observations †, must, in my opinion ‡, be quite separated from the Florideæ, and for this reason no reference has been made to it in the above description. For the establishment of this opinion the most important points in the developement of the Bangiaceæ which distinguish them from the Florideæ may therefore be briefly indicated here.

In the first place, the construction of the thallus of the Bangiaceæ is essentially different from that of the Florideæ. In the Bangiaceæ transverse division of the joint-cells takes place in an unlimited degree, and numerous longitudinal divisions of the cells are produced by partitions which occupy the organic middle line of the cells, neither of which ever happens in the Florideæ. In consequence of this also the thallus of the Bangiaceæ, so long as it does not actually represent a simple cell-filament, can never be reduced to a mere system of branched fibres. Further, the vegetative thallus-tissue of the Bangiaceæ is also always quite destitute of the remarkably characteristic primary pits of the Florideæ, which are formed in unity in the organic centre of each newly formed dissepiment.

Further, the sexual cells of the Bangiaceæ are formed from any cells of the thallus, while in the Florideæ they are formed exclusively from terminal cells of longer or shorter cell-filaments. For the formation of the spermatia, in most Bangiaceæ (*Bangia*, *Porphyra*), the individual thallus-cell breaks up by repeated division by means of dissepiments perpendicular to each other into a pluricellular complex of small cells,

* An opposite opinion has been recently expressed by Falkenberg (Schenk, Handb. der Bot. Bd. ii. pp. 252, 253) and Berthold ('Fauna und Flora des Golfes von Neapel, VIII. Bangiaceæ,' p. 22).

† Mittheil. aus der zool. Station zu Neapel, ii. pp. 78 *et seqq.*, and Fauna und Flora des Golfes von Neapel, Bd. viii.

‡ See Schmitz, Chromatophoren der Algen, p. 3, note 1.

which are all alike, and each of which gives origin to a single spermatium *; in the Florideæ the spermatia always originate only from superficial cells, terminal cells, or branch-cells of the cell-filaments of the thallus †. In the Bangiaceæ the individual thallus-cells, without distinction, become converted into female cells, extending a short diverticulum on the outer surface of the thallus, which usually hardly even distantly resembles the trichogyne of the always terminal carpogonia of the Florideæ ‡. In the act of fecundation in the Bangiaceæ, moreover, the whole protoplasm of the spermatium, except a very small residue §, passes over into the female cell, which then retracts the above conjugation-process, and becomes converted into the fertilized ovicell, without separating off the directive body which is so characteristic of the Florideæ. Lastly, in the Bangiaceæ, this fecundated ovicell either becomes directly the spore (*Erythrotrichia*, according to Berthold, *l. c.* p. 17), or breaks up by repeated division into a complex of more or less numerous cells, all of which give origin to single naked spores; a sporigenous tuft of threads with a sterile central cell, as in the cystocarp of the Florideæ, is here never produced.

In my judgment, all these peculiarities distinguish the Bangiaceæ very essentially from the Florideæ ||, which, with all their other differences of construction, display a complete agreement in the points mentioned. Consequently the Ban-

* In *Erythrotrichia*, however, according to Berthold (Bangiaceæ, p. 13) the spermatia are formed from marginal cells of the individual joint-cells of the thallus.

† I would lay less stress upon the further fact that, as Berthold states (*l. c.* pp. 12, 13), in the Bangiaceæ the spermatia always contain formed chromatophores with pyrenoids [see Schmitz, 'Die Chromatophoren,' &c.], while in the Florideæ, the spermatia, so far as my present observations extend, are always destitute of chromatophores.

In passing it may be here once more (see Schmitz, 'Chromatophoren der Algen,' p. 39, note 1) indicated that Berthold everywhere confounds the pyrenoids of the chromatophores with the cell-nuclei, but has overlooked the true cell-nuclei in the cells of the Bangiaceæ. I took up the investigation of this question again after the appearance of Berthold's recent memoir, in which his previous statements are simply repeated; but this time also I find my above-cited statements about the cell-nuclei and pyrenoids of the Bangiaceæ completely confirmed.

‡ Compare figs. 2, 4, 12, 13, 23, and 24 in Berthold, *l. c.*

§ See also Berthold's statements, *l. c.* pp. 14 *et seqq.*

|| Berthold (Bangiaceæ, p. 21) thinks, on the contrary, that the characters of structure and growth of the thallus, with reference to which the Bangiaceæ stand quite isolated among the Florideæ, but correspond with the Ulvaceæ and Ulotricheæ (*l. c.* p. 1), are of no importance with regard to the systematic position of the Bangiaceæ.

giaceæ must at least be separated as a distinct group from the very coherent group of the Florideæ*.

But it seems to me that this peculiar group of the Bangiaceæ cannot be placed close to the Florideæ as the most nearly allied group in the natural system. The agreement of the Bangiaceæ with the Florideæ depends fundamentally only upon a few subordinate points. In both groups of Algæ the chromatophores are generally not chlorophyll-green, but coloured with various shades of red or brown ; in both groups of Algæ the male cells are not motile (so far as is at present ascertained †) ; in both groups of Algæ the fertilized ovicell produces, without a period of rest, usually a considerable number of asexual spores. Nearly all these individual characters also occur in other groups of Algæ (*e. g.* even the Dictyotaceæ likewise possess motionless male cells, for which reason they have also sometimes been regarded as Florideæ) ; but, in my judgment, they do not of themselves alone establish an *immediate* relationship between the Bangiaceæ and Florideæ. I rather believe, as I have already stated briefly elsewhere ‡, that, in the natural system of the Thallophyta, the Bangiaceæ are to be placed alongside of the Chlorophycean group of the Schizogoneæ (*Prasiola, Schizomeris, Schizogonium, Palmoglœa, Porphyridium*) ; while the Florideæ certainly attach themselves through the Coleochæteæ to the main stem of the Algæ, the Chlorophyceæ §, but are separated by a sufficiently wide gap from these Chlorophyceæ, and represent a group sufficiently large, numerous in forms, and peculiarly developed to be judiciously distinguished as a special, independent section of the Algæ, the Rhodophyceæ.

The results of the extant investigations upon the fructifi-

* Even the conception of the Bangiaceæ as a peculiar branch of the Florideæ, which has branched off from the very base of this great Algal stem, cannot prevent the otherwise so perfectly harmonious ramification of this Algal stem from being seriously interfered with by this very branch.

† Hitherto the faculty of free locomotion is ascribed only to the spermatia of *Erythrotrichia* by Berthold (*l. c.* p. 13). But at present we are quite without any statements in what manner this locomotion is effected. Compare herewith the above statements (p. 9, note *) upon the spontaneous mobility of the spermatia of the Florideæ.

‡ Schmitz, 'Chromatophoren der Algen,' p. 3, note 1.

§ By this arrangement the relationship of the Florideæ with the Bangiaceæ, so far as this actually exists, is also expressed, in my judgment, in a perfectly satisfactory manner; for by the approximation of the Florideæ to the Coleochæteæ the former also join on to the other groups of the Chlorophyceæ, and thereby also to the Bangiaceæ. Nevertheless the Bangiaceæ and Florideæ are certainly here torn more widely asunder than has usually been the case of late.

cation of the Florideæ furnish also some contributions to the classification of this section of the Algæ.

At present, as is well known, we have only the commencement of a natural system of the Florideæ. Our present knowledge of the group, which includes such an abundance of forms, is still too imperfect for it to be possible as yet to establish a natural system of these Algæ. For the present we must make artificial systems answer our purpose, and these are now founded entirely upon the structure of the mature cystocarp (J. Agardh), a preponderant consideration of the growth of the thallus (Nägeli) having proved to be unsuitable. A consistent carrying through of this principle of division, however, frequently tears the nearest allies wide apart (*e. g.* *Delesseria* and *Hydrolapathum*, *Chylocladia* and *Lomentaria*, *Griffithsia* and *Bornetia*, &c.).

For the advancement of the natural system of the Florideæ an exact investigation of the processes in the fructification of the different individual forms is, in my opinion, essentially necessary. It would, however, lead me too far to enumerate here in detail the results which I think I can deduce from my investigations towards the natural system of the Florideæ. The more general results of this kind have already had expression given to them in the above statement in the arrangement of the groups. A more thorough-going representation of them will only be indicated when we have been able to investigate exactly a far greater number of forms than at present with regard to their fructification.

EXPLANATION OF THE PLATES.

Plate I.

Fig. 1. *Batrachospermum moniliforme*, Roth.
(Picric-acid-Hæmatoxyline preparation.)

Apex of the carpogonial branch with the carpogonium already fertilized; trichogyne separated off from the ventral part of the carpogonium, and the latter sprouting forth laterally. The hypogynal cell develops beside the older ramified side-branch a new lateral sprout as the foundation of a new sterile enveloping branch. In the ovicell, the hypogynal cell, and the branch-cells of both sides the nucleoli of the cell-nuclei are intensely coloured; within the trichogyne the protoplasm encloses a number of intensely coloured granules (derivatives of the cell-nucleus of the female cell?). × 800 diam.

Figs. 2–4. *Chantransia corymbifera*, Thur.
(Spirit-material, relaxed in water and coloured with hæmateine-ammonia.)

Fig. 2. In the fertilized carpogonium the trichogyne is separated off by means of the membranous stopper within the neck of the trichogyne. The fecundated ovicell forms an offshoot upwards, which has already been separated off by a transverse wall. × 800.

Fig. 3. Next stage of development. Besides the terminal offshoot a second offshoot is commenced laterally. × 800.

Fig. 4. Further stage of development. × 800.

Figs. 5–7. *Scinaia furcellata*, Bv.

(Spirit-specimen.)

Fig. 5. Young carpogonial branch. In the terminal carpogonium the formation of the trichogyne has just commenced. The hypogynous cell has already formed a marginal cell for the production of the hypogynous disk. On the lowest cell of the carpogonial branch has commenced the sprouting forth of the enveloping filaments, which subsequently close together to form the fruit-wall. × 800.

Fig. 6. Four-celled hypogynous disk, with the separated ventral part of the just fecundated carpogonium. × 800.

Fig. 7. The fertilized ovicell (still furnished at the apex with the closed neck of the trichogyne) has projected at one side, and developed an abundantly ramified tuft of ooblastema-threads (the formation of which by no means proceeds from the cells of the hypogynous disk, as has hitherto been supposed). × 800.

Figs. 8–15. *Glœosiphonia capillaris*, Carm.

(Spirit-material.)

Fig. 8. Young procarpium from the side. *b*, basal cell of the whole procarpial branch, the penultimate cell (*a*) of which (the terminal cell is bent laterally and in the figure concealed by the cell *a*) becomes the auxiliary cell. This basal cell bears, as a side-branch, the three-celled carpogonial branch, the terminal cell of which has already developed a long trichogyne, while the hypogynous cell has projected very much on one side (*h*) and become abundantly filled with protoplasm. The second cell of the procarpial branch bears laterally a sterile side-branch. × 800.

Fig. 9. Young procarpium from below. *b*, basal cell of the entire procarpial branch, the joint-cells of which are separated by differently inclined transverse walls, and have nearly all formed sterile lateral branches, while the penultimate cell (*a*) becomes the auxiliary cell. The basal cell bears as a side-branch the three-celled carpogonial branch, the hypogynous cell (*h*) of which has here remained much smaller than in fig. 8. × 800.

Fig. 10. Carpogonial branch. In the fertilized carpogonium the ventral part is separated and has grown out into a single ooblastema-thread (*c*), which, near its base, has developed a side-branch (*c'*). The ventral part of the carpogonium is completely emptied; the hypogynous cell (*h*) has still abundant contents. × 800.

Fig. 11. Auxiliary cell (*a*) at the apex of the procarpial branch (seen from below) in open conjugation with the ooblastema-cell (*e*). × 800.

Fig. 12. Procarpial branch seen from below. The basal cell (*b*) and the neighbouring joint-cell each bear laterally a carpogonial branch, of which in the figure only the lowest cell (*d*) is shown. The auxiliary cell (*a*) had entered into conjugation with the ooblastema-cell (*e*), and, after the transference of the whole of the protoplasm from *e*, has again closed up as an independent cell with abundant contents. × 800.

Fig. 13. Apex of the procarpial branch with the fertilized auxiliary cell *a*, from the side. × 800.

Fig. 14. The same. The fertilized auxiliary cell (*a*) has separated off outwards the central cell of the spore-complex. × 800.

Fig. 15. The same, further stage of development. The central cell separates off successive marginal cells. × 800.

Figs. 16–19. *Dudresnaya purpurifera*, J. Ag.
(Spirit-material.)

Fig. 16. Carpogonial branch, with the apex bent inwards. From the ventral part of the fertilized carpogonium, which is already separated off, an ooblastema-thread grows out, and takes a direction towards the auxiliary cells, which are formed by the terminal cells of short side-branches of the carpogonial branch. × 800.

Fig. 17. The same. From the ventral part of the fertilized carpogonium two short ooblastema-threads have grown out and have conjugated with certain (one or two) auxiliary cells. One of these short filaments pushes out a side-branch (*c*), which grows out into the neighbouring thallus-tissue. × 800.

Fig. 18. The apex of an ooblastema-thread growing close past an auxiliary cell, which here forms the terminal cell of a special branch. × 800.

Fig. 19. Later stage of development of fig. 18. The growing apex of the ooblastema-thread has cut off a joint-cell, and this has entered into conjugation with the auxiliary cell. Afterwards the ooblastema-cell has formed a diverticulum outwards, and separated this off as an independent cell for the formation of the spore-complex. × 800.

Figs. 20 and 21. *Dudresnaya coccinea*, Crouan.
(Spirit-material.)

Fig. 20. The apex of an ooblastema-thread has grown close past an auxiliary cell, which here forms a joint-cell in a special branch; the separated joint-cell of the ooblastema-thread enters into conjugation with this auxiliary cell, the two neighbouring cells of which are also richly filled with protoplasm.

Fig. 21. A further stage of development. The joint-cell of the ooblastema-thread (*c c*) has formed outwardly an offshoot (*c'*), which grows into a side-branch of the ooblastema-thread, and also two lateral offshoots (*e*, *e*), which apply themselves to the auxiliary cell externally, and grow round it, to give origin afterwards to the spore-complex of the cystocarp. × 800.

Fig. 22. *Dumontia filiformis*, Grev.
(Spirit-material.)

Carpogonial branch, bent into a hook. The formation of the trichogyne has already commenced on the terminal carpogonium. × 800.

Plate II.

Fig. 23. *Calosiphonia finisterræ*, Crouan.
(Treated with picric acid and hæmatoxylin.)

Three-celled carpogonial branch. The lowest cell is much enlarged, like an auxiliary cell, but does not function as such. From the separated ventral part of the fertilized carpogonium three ooblastema-threads grow forth and diffuse themselves into the neighbouring thallus-tissue. × 800.

Figs. 24–27. *Naccaria hypnoides*, J. Ag.

(Material in spirit.)

Fig. 24. Young carpogonial branch (*b, d, e*) with incurved apex. Its basal cell (*b*) bears laterally two branch-cells (*a*), which subsequently develop into auxiliary cells. × 800.

Fig. 25. Later stage of development. The cell *d* of fig. 24 has formed laterally a branch-cell, *f*; the cell *e* has divided itself by an oblique transverse wall into the terminal cell *g* and the joint-cell *e*, so that now the cells *b d e g* form the uncinately incurved carpogonial branch. × 800.

Fig. 26. Further stage of development. The cells *d, e*, and *f* have repeatedly branched and formed a small-celled hypogynous cell-complex. The cell *g* has become developed into the carpogonium, and upon this, after fertilization, the trichogyne has become separated off from the ventral part. × 800.

Fig. 27. A still later developmental stage. The ventral part of the fertilized carpogonium has entered into conjugation with the basal cell (*b*) of the carpogonial branch, and now puts forth an ooblastema-thread (*c*). *t*, remains of the trichogyne, which is here very transitory. (The fertilized ovicell also enters into conjugation with the auxiliary cells *a* in fig. 24 through short processes in a very variable manner, after which fresh ooblastema-threads originate from the conjugation-cell; these processes, however, have been omitted from the figure for the sake of distinctness.) × 800.

Fig. 28. Diagram of the cell-division in the procarpium (median longitudinal section) of *Chondria*, *Polysiphonia*, and other Rhodomeleæ.

b, cell of the central axis of the procarpial branch; *a*, unpaired marginal cell of this, from which in the first place the curved carpogonial branch, *e e e c*, grows forth as a terminal growth, while laterally one or more branch-cells, *d*, are produced; these sometimes (as in *Chondria tenuissima*) ramify very abundantly, and form a complex of short, closely adpressed, *sterile* cell-filaments. The cell *a* itself subsequently becomes the auxiliary cell, and, after the fertilization of the carpogonium (*c*), is fertilized by the separated ventral part of this carpogonium, with which it is in contact at the time of fertilizable maturity. From the cell *a* the sporigenous filaments then shoot forth, while the cell-series *e e e*, as well as the sterile tuft of filaments of the cell *d*, disappears.

Figs. 29–33. *Chylocladia kaliformis*, Hook.

(Material in spirit.)

Fig. 29. One of the short-jointed cell-filaments, which, meeting at the apex, constitute the growing vertex of the branches of the thallus. The joint-cells of this cell-filament branch outwards to form the large-celled layer of the wall of the hollow joints of the thallus. From the branch-cell of the sixth joint-cell there shoots forth laterally an uncinately curved carpogonial branch. Drawn without the camera.

Fig. 30. The sixth joint-cell of fig. 29, with the adherent carpogonial branch, more highly magnified and drawn with the camera. The newly-formed trichogyne of the carpogonium strongly inflated at its base on one side. *b*, supporting cell of the carpogonial branch. × 800.

Fig. 31. Young rudiment of a cystocarp seen from the outside of the thallus. The shaded cells represent the carpogonial branch : *c*, the ventral part of the carpogonium, the trichogyne of which was segmented off after fertilization and has perished; the dotted cell, *b*, the supporting cell of the carpogonial branch. *a*, the auxiliary cell, which bends towards the fertilized ovicell (*c*) with a broad conjugation-process ; *m*, one of the large cells of the wall of the thallus-joint, which has separated off the auxiliary cell (*a*) externally as a daughter-cell. This entire cell-group is covered by numerous small marginal cells, which the neighbouring cells have separated off, and which form the first rudiment of the future wall of the cystocarp. × 300.

Fig. 32. An auxiliary cell with a broad curved conjugation-process, seen from the side. × 800.

Fig. 33. Carpogonial branch with fully-developed carpogonium. A spermatium has conjugated with the apex of the trichogyne. × 800.

Fig. 34. *Callithamnion gracillimum*, Harv.

(Material in spirit.)

Procarpium. On one of the uppermost joint-cells of a completed branch of the thallus there stand in a whorl the sterile branch-cells (*b*), the two auxiliary cells (*a*), one of which has also segmented off a cell (*d*) on its outer side, and the three-celled carpogonial branch (*e e c*). × 800.

Fig. 35. *Pterothamnion plumula*, Näg.

(Osmic acid and hæmatoxylin preparation.)

Procarpium. The basal cell (*b*) of a frond-pinna bears upon one side the curved four-celled carpogonial branch, and on the other side the auxiliary cell (*a*). The latter has curved over towards the upper surface of the basal cell, and so comes in contact with the ventral part of the carpogonium, which has already separated from the trichogyne, as the fertilized ovicell, by means of a very short and dense closing-plate (*p*). × 800.

Fig. 36. *Polysiphonia atrorubescens*, Grev.

(Picric acid and hæmatoxylin preparation.)

Young procarpium in median optical longitudinal section. On the joint-cell *b* of the central axis the unpaired marginal cell *a* has segmented off a terminal offshoot, which already consists of two cells, and by the development of further transverse walls in the terminal cell will grow into the curved carpogonial branch of the fertilizably mature procarpium (fig. 28). × 800.

Figs. 37 and 38. *Plocamium coccineum*, Lyngb.
(Spirit-material.)

Fig. 37. Young fruit-rudiment at the period of fertilizable maturity. A spermatium has conjugated with the extended trichogyne. × 150.

Fig. 38. Longitudinal section through a still younger fruit-rudiment, the apex of the trichogyne of which has not yet got free. An internal tissue-cell (*a*) has developed, as a secondary side-branch, a three-celled carpogonial branch (*e e c*), and itself become developed into the auxiliary cell, extending a conjugation-process towards the ventral part of the carpogonium. The trichogyne is much inflated in a clavate form above the neck before, breaking through the surface of the thallus with its dense cuticle, it protrudes as a long thin hair. × 400.

Fig. 39. *Caulacanthus ustulatus*, Kütz.
(Spirit-material.)

Longitudinal section through a young fruit-branch: *m m*, central axis. A side-branch of this central axis bears laterally on a joint-cell (*d*) the carpogonial branch (*e e c*). The lowest cell of this grows into a sterile rhizoidiform thread. The uppermost cell has developed into the carpogonium; its ventral part has become segmented off after fertilization, and has grown out into a single ooblastema-thread, which, branching abundantly, coils itself about the central axis. At × originated another ramified side-branch of the ooblastema-thread, which spread out upon the under surface of the central axis, but has been omitted in the figure for the sake of distinctness. × 400.

X.—*Contributions to the Knowledge of the Freshwater Sponges.* By Dr. F. VEJDOVSKY, of Prague. *With Remarks by* H. J. CARTER, F.R.S. &c.

[Plate VI.]

THE above is a translation of the Title of a memoir communicated by Dr. F. Vejdovsky to the Society of Science in Prague, on the 12th October last, and since printed in the Bohemian language, with the following *Résumé* in German:—

RÉSUMÉ*.

In my monograph of the freshwater sponges of Bohemia† I left two questions, among others, open, to be answered by subsequent investigations.

The first question relates to the multiform "*Ephydatia*

* Translated from a separate impression of the Memoir sent by the author to Mr. H. J. Carter, F.R.S.

† "Revisio Faunæ Bohemicæ. Pars I. Die Süsswasserschwämme Böhmens." Von Dr. Franz Vejdovsky in Prag (mit 3 lithographirten Tafeln). Abhandl. d. k. Böhm. Gesellsch. der Wiss. Folge 6, Band xii.